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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P012805WO MJH	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/GB02/05355	International filing date *(day/month/year)* 28.11.2002	Priority date *(day/month/year)* 07.12.2001
International Patent Classification (IPC) or both national classification and IPC G01V3/12		
Applicant UNIVERSITY OF SOUTHAMPTON et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 8 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
14.05.2003	09.12.2003
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Thomas, J Telephone No. +49 89 2399-2226

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB02/05355

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

1-31 as originally filed

Claims, Numbers

1-31 received on 04.11.2003 with letter of 04.11.2003

Drawings, Sheets

1/6-6/6 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-31
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-31
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-31
	No:	Claims	

2. Citations and explanations

   see separate sheet

1. **Closest state of the art**
Document **US-A-4 617 518** is considered as closest prior art. It shows a towing arrangement for an electromagnetic survey, wherein an electric dipole array is installed in an end-on position and two of the electromagnetic array detectors are installed in a broadside position. However, the whole arrangement is towed behind a vessel, and in particular the configuration between the source with respect to the receivers is provided in a fixed configuration during the whole survey.
The publication of **MacGregor et al.**: 'Electrical resistivity structure of the Valu Fa Ridge, Lau Basin, from marine controlled-source electromagnetic sounding' Geophysical Journal International (**XP002234785**; ISSN: 0956-540X), and cited in the application, indicates that the source is towed behind a vessel, whereas the receivers are installed on the sea bottom. However, no further specific indication is given concerning a particular source-receiver configuration.

2. **Novelty (Art. 33(1,2) PCT)**
The subject-matter defined in any of the independent claims 1, 4, 20-22, 30 and 31 is novel over the available state of the art, because none of the available documents shows a method using two complementary data sets of an electromagnetic survey, wherein each data set is recorded using a source movable relative to static receivers, and in particular not in the defined configuration concerning their end-on and broadside position.

3. **Inventive step (Art. 33(1,3) PCT)**
US-A-4 617 518, which cites the recording of different data-sets, does neither record the data-sets in the cited particular complementary configuration (end-on and broadside configuration with the respective sensitivities), nor with static receivers and a movable source. There is no indication given to combine the shown subject-matter with any of the other document in order to obtain a broadside and an end-on configuration with a movable source such that the sensitivities either for galvanic and or inductive effects are dominant in the complementary data-sets. An inventive contribution over the prior art (Art. 33(1,3) PCT) is consequently acknowledged.
The only document which indicates the use of static receivers compared to a movable source for an electromagnetic survey is the document of **MacGregor et al. (XP002234785)** which does not give any indication to use the particular combination of two complementary data-sets.

4. **Industrial applicability (Art. 33(1,4) PCT)**

There is no doubt about the industrial applicability in particular in the field of geophysical exploration.

5. Dependent claims

All of the dependent claims concerns particular arrangements of the subject-matter defined in the claims on which they depend and are consequently also novel, inventive and industrial applicable.

6. Further remarks

6.1 Claim 10 is considered as a claim dependent on any of the preceding claims (Art. 6 PCT).

6.2 Independent claims 1, 4, 20-22, 30 and 31 are not in the two-part form in accordance with Rule 6.3(b) PCT.

6.3 The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

CLAIMS

1. An electromagnetic survey method for surveying an area previously identified as potentially containing a subsea hydrocarbon reservoir, comprising:

providing an electromagnetic source having a dipole axis and first and second detectors;

obtaining first and second survey data sets by moving the electromagnetic source relative to each detector to collect data over a range of source-to-detector distances,

wherein the first survey data set is obtained with the dipole axis of the electromagnetic source aligned end-on relative to the first detector so that the first survey data set is sensitive to resistive hydrocarbon layers exploiting largely galvanic effects, and

wherein the second survey data set is obtained with the dipole axis of the electromagnetic source aligned broadside relative to the second detector so that the second survey data set is relatively insensitive to resistive hydrocarbon layers exploiting dominantly inductive effects.

2. An electromagnetic survey method according to claim 1, wherein the first and second survey data sets are obtained concurrently.

3. An electromagnetic survey method according to claim 1 or claim 2, wherein a right angle is formed between a first line leading from the first detector to the electromagnetic source and a second line leading from the second detector to the electromagnetic source.

4. An electromagnetic survey method for surveying an area previously identified as potentially containing a subsea hydrocarbon reservoir, comprising:

providing an electromagnetic source having a dipole axis and a first detector;

obtaining first and second survey data sets by moving the electromagnetic source relative to the first detector to collect data over a range of source-to-detector distances and orientations,

wherein the first survey data set is obtained with the dipole axis of the electromagnetic source aligned end-on relative to the first detector so that the first survey data set is sensitive to resistive hydrocarbon layers exploiting largely galvanic effects, and

wherein the second survey data set is obtained with the dipole axis of the electromagnetic source aligned broadside relative to the first detector so that the second survey data set is relatively insensitive to resistive hydrocarbon layers exploiting dominantly inductive effects.

5. An electromagnetic survey method according to claim 4, wherein the first and second survey data sets are obtained consecutively.

6. An electromagnetic survey method according to claim 4 or claim 5, wherein the electromagnetic source is moved in a direction along a line connecting the electromagnetic source to the detector to obtain one of the first and second survey data sets and again transverse thereto to obtain the other of the first and second survey data sets.

7. An electromagnetic survey method according to any one of the preceding claims, wherein the electromagnetic source is a mobile horizontal electric dipole source equipped with a streamed antenna which is towed above the seafloor to obtain the first and second survey data sets.

8. An electromagnetic survey method according to any one of the preceding claims, wherein each detector is static while the first and second survey data sets are obtained.

9. An electromagnetic survey method according to claim 8, wherein each detector is placed on the seafloor while the first and second survey data sets are obtained.

10. A method of analysing results from an electromagnetic survey of an area potentially containing a subsea hydrocarbon reservoir, comprising:

providing first and second survey data sets obtained using the method of any one of the preceding claims; and

combining the first and second survey data sets to obtain a results data set that represents a difference between the end-on and broadside alignments as a function of the source-to-detector distances surveyed.

11. A method of analysing results from an electromagnetic survey according to claim 10, further comprising:

normalising each of the first and second survey data sets relative to respective first and second normalisation data sets or functions specific to the end-on and broadside alignments respectively, prior to the combining.

12. A method of analysing results from an electromagnetic survey according to claim 11, wherein the first and second normalisation data sets or functions are calculated from a rock formation model.

13. A method of analysing results from an electromagnetic survey according to claim 11, wherein the first and second normalisation data sets or functions are calculated from the first and second survey data sets.

14. A method of analysing results from an electromagnetic survey according to any one of claims 10 to 13, wherein the first and second data sets each comprise radial

and azimuthal components of electric field or magnetic field measured at the detector, the method further comprising:

transforming the radial and azimuthal components into at least one polarisation ellipse parameter, prior to the combining.

15. A method of analysing results from an electromagnetic survey according to claim 14, wherein the at least one polarisation ellipse parameter is the amplitude and/or phase of the component of the electric field or magnetic field aligned along a major axis of the ellipse.

16. A method of analysing results from an electromagnetic survey according to any one of claims 10 to 15, further comprising:

visually representing the results data set in a plot of at least two dimensions corresponding to the survey area.

17. A method of analysing results from an electromagnetic survey according to claim 16, wherein the plot includes markings of areas of equal or similar electromagnetic field strength.

18. A method of analysing results from an electromagnetic survey according to claim 17, when appended to any one of claims 11 to 13, wherein the plot includes lines of equal absolute electromagnetic field strength.

19. A computer program product bearing machine readable instructions for implementing a method of analysing results from an electromagnetic survey according to any one of claims 10 to 18.

20. A computer apparatus loaded with machine readable instructions for implementing the method of analysing results from an electromagnetic survey according to any one of claims 10 to 18.

21. A method of planning an electromagnetic survey of an area identified as potentially containing a subsea hydrocarbon reservoir, comprising:

creating a model of the area to be surveyed, including a rock formation containing a hydrocarbon reservoir and a body of water above the rock formation;

setting values for water depth, depth below the seafloor of the hydrocarbon reservoir, and resistivity structure of the rock formation;

performing a simulation of an electromagnetic survey in the model of the survey area by calculating first and second survey data sets by simulating an electromagnetic source having a dipole axis and first and second detectors and moving the electromagnetic source relative to each detector to collect data over a range of source-to-detector distances, wherein the first survey data set is obtained with the dipole axis of the electromagnetic source aligned end-on relative to the first detector so that the first survey data set is sensitive to resistive hydrocarbon layers exploiting largely galvanic effects, and wherein the second survey data set is obtained with the dipole axis of the electromagnetic source aligned broadside relative to the second detector so that the second survey data set is relatively insensitive to resistive hydrocarbon layers exploiting dominantly inductive effects; and

combining the first and second survey data sets to obtain a results data set that represents a difference between the end-on and broadside alignments as a function of the source-to-detector distances.

22. A method of planning an electromagnetic survey of an area identified as potentially containing a subsea hydrocarbon reservoir, comprising:

creating a model of the area to be surveyed, including a rock formation containing a hydrocarbon reservoir and a body of water above the rock formation;

setting values for water depth, depth below the seafloor of the hydrocarbon reservoir, and resistivity structure of the rock formation;

performing a simulation of an electromagnetic survey in the model of the survey area by calculating first and second survey data sets by simulating an electromagnetic source having a dipole axis and a first detector and moving the electromagnetic source relative to the first detector to collect data over a range of source-to-detector distances and orientations, wherein the first survey data set is obtained with the dipole axis of the electromagnetic source aligned end-on relative to the first detector so that the first survey data set is sensitive to resistive hydrocarbon layers exploiting largely galvanic effects, and wherein the second survey data set is obtained with the dipole axis of the electromagnetic source aligned broadside relative to the first detector so that the second survey data set is relatively insensitive to resistive hydrocarbon layers exploiting dominantly inductive effects; and

combining the first and second survey data sets to obtain a results data set that represents a difference between the end-on and broadside alignments as a function of the source-to-detector distances.

23. A method of planning an electromagnetic survey according to claim 21 or 22, further comprising:

repeating the simulation for a number of source frequencies in order to select optimum surveying conditions in terms of source frequency and source-to-detector distances for probing the hydrocarbon reservoir.

24. A method of planning an electromagnetic survey according to claim 21, 22 or 23, wherein the model includes a body of air above the body of water, and wherein the simulation takes account of signal propagation paths including the body of air when calculating the first and second survey data sets.

25. A method of planning an electromagnetic survey according to any one of claims 21 to 24, further comprising:

normalising each of the first and second survey data sets relative to respective first and second normalisation data sets or functions specific to the end-on and broadside alignments respectively, prior to the combining.

26. A method of planning an electromagnetic survey according to any one of claims 21 to 25, wherein the first and second data sets each comprise radial and azimuthal components of electric field or magnetic field measured at the detector, the method further comprising:

transforming the radial and azimuthal components into at least one polarisation ellipse parameter, prior to the combining.

27. A method of planning an electromagnetic survey according to any one of claims 21 to 26, further comprising visually representing the results data set in a plot of at least two dimensions corresponding to the survey area.

28. A method of planning an electromagnetic survey according to claim 27, wherein the plot includes markings of areas of equal or similar electromagnetic field.

29. A method of planning an electromagnetic survey according to claim 28, when appended to claim 25, wherein the plot includes lines of equal absolute electromagnetic field strength.

30. A computer program product bearing machine readable instructions for implementing the method of planning an electromagnetic survey according to any one of claims 21 to 29.

31. A computer apparatus loaded with machine readable instructions for implementing the method of planning an electromagnetic survey according to any one of claims 21 to 29.